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ABSTRACT

The primary objective of the Project to Increase Mastery of Mathematics and Science (PIMMS) is to bring high quality staff development in mathematics and science to teachers of all levels. This report describes the progress PIMMS has made over the past 12 years in fostering an appreciation of mathematics and science by teachers in the state of Connecticut. The report sets forth the project's future visions along with its goals and objectives, and the effects the project has had on different individuals and institutions committed to science and mathematics education, especially in the past 5 years. The report used interview data collected during the summer of 1995 and additional supportive material provided by the project itself to document general findings. Data indicated that PIMMS plays a pivotal role in promoting significant improvement in the teaching and learning of mathematics and science in schools. It is concluded that PIMMS has realized and will continue to realize its goals and objectives and that the project is making very substantial improvements in science and mathematics education by providing effective professional development programs to committed teachers, who in turn teach and influence their colleagues. Sections of the report include introduction, analysis of data and methodology, challenge for PIMMS, findings, themes and conclusions, and recommendations. (JRH)

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PIMMS

A Summative Report of the Project to Increase Mastery of Mathematics and Science

Charles Bruckerhoff
Curriculum Research and Evaluation

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September 15, 1995

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Addendum

Soon after the Report on PIMMS was filed, the PIMMS staff provided the following response. We concur with these observations and include them at the beginning, because we believe they add an important dimension to the report itself.

> *Many thanks to you and your associates for a careful evaluation of PIMMS and its performance over the past decade or so! It is encouraging to those of us who have invested substantial time and energy in this effort to improve education in mathematics and science to learn that you confirm the effectiveness of what we have been doing. But there is still a long way to go!*
>
> *Our satisfaction is enhanced because your work was autonomous, without "meddling" by PIMMS staff. Precisely because of that circumstance, it may be useful to have the following observations as a supplement to the Report and as a commentary on your Recommendations.*
>
> ***(1) Data on Improvement in Student Performance.** In your Preface and again at several points in the body of the document, you regret the paucity of hard evidence of improvement in student performance, e.g., through increases in scores on the CMT. As you note on p. 36, had there been time for comprehensive analyses of other communities, as was done with Montville and Stratford, you might have found more statistically significant data, comparable to what you found in those two communities. We suggest that, in a future evaluation of PIMMS, we devote more resources to such community analyses as a supplement to questioning individuals, who may not have a District's data at their fingertips. Indeed, we believe that you agree with us that an in-depth study, in the spirit of the Lynd's classic "Middletown", could be of real value to those working to improve the quality of life in our State.*
>
> *As you note on p. 41, your recommendations are based on suggestions made by subjects of the study. Some of those subjects may not be up-to-date about current PIMMS practices. Moreover, you recognize that PIMMS is already addressing some of the recommendations. The comments that follow are restricted to those recommendations that PIMMS has not fully addressed.*
>
> ***(2) Recommendation. "...increase the number of seats so that more can participate."** Partly because we have reached the limits on what facilities Wesleyan can provide, we have instituted the "One-Week Institutes" dispersed around the State, often sited at installations of business and industry. The dramatic growth of enrollment in these Institutes testifies to their meeting a need.*

(3) Recommendation. "Provide shorter workshops...during the school year.."

*(a) follow-up sessions during the school year have **always** been an integral part of our summer programs. We have begun to increase the scope of these sessions from two or three days to the equivalent of five full days.*

(b) As we have done in Shelton, we respond to requests for "tailored" programs, extending over a semester or a year.

(c) Our on-site inservice programs are useful here—see (8) below.

(4) Recommendation. "Reinstate the high school summer fellowship program."

(a) We offer a high school fellowship program now—the Mathematics Technology Institute.

(b) We also offer several One-Week Institutes for high school teachers.

(c) We will likely return to a high school fellowship program, focused on a theme, when resources permit.

***(5) Recommendation. "Train a few substitutes..."** We propose to do this in connection with our on-site inservice programs.*

(6) Recommendation. "Help teachers...reach out to parents..."

(a) This is addressed in the portions of our programs devoted to helping teachers act as agents of change.

(b) It will be a theme in our institutes for administrators and school board members.

***(7) Recommendation. "...establish a critical mass..."** Our plans for the next five years include **focusing** our efforts to do this.*

***(8) Recommendation. "Obtain long-term funding..."** We would welcome long-term funding!*

***(9) Recommendation. "Provide competitive stipends..."** We believe that our stipends are appropriate. We have **decreased** stipends as teachers' salaries have increased.*

(10) Recommendation. "...to provide release time..." *This is a vexing issue. Although our Fellows' application forms require their administrators' agreement to facilitate opportunities for dissemination among the Fellows' colleagues of PIMMS ideas on content and pedagogy the "multiplier effect"), some administrators do not in fact honor their commitment. This is understandable in a period of financial stringency, but such reneging reduces PIMMS' effectiveness and increases teachers' feelings of frustration.*

(11) Recommendation. "...refresher courses and reunions..."

(a) *We now plan yearly reunions for all Fellows at the time of the Shackleton Memorial Lecture.*

(b) *We are developing regional reunions around the State*

(c) *We have a short reunion (three days or so) on campus during the summer for groups of Fellows.*

Thanks again for your good work!

Sincerely yours,

Dan Dolan	*Robert A. Rosenbaum*	*Wilma Toney*
Director,	*Chair,*	*Associate Director,*
PIMMS	*PIMMS*	*PIMMS*

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Preface

This report describes the progress PIMMS has made over the past twelve years to foster greater command, understanding, and appreciation of mathematics and science by teachers in the state of Connecticut. The report sets forth the project's future visions, along with its goals and objectives, and the effects the project has had on different individuals and institutions committed to science and mathematics education in the state, especially in the past five years. This report covers the achievements of PIMMS as described by the project personnel, teachers, school administrators, college and university professors, Connecticut State Department of Education consultants, and also as reported in newsletters and other documents. It includes recommendations aimed at sustaining and increasing the effects of PIMMS.

Briefly, PIMMS is a highly successful program for the professional development of mathematics and science teachers in the state of Connecticut. Its administration, operations, materials, and personnel are first-rate. Teachers and school administrators, who are the principal beneficiaries of PIMMS, think that it is the best in-service program available anywhere. PIMMS effectively meets the needs for improving teachers' content area knowledge, curriculum development, and teaching methods. Furthermore, PIMMS is continually responding in positive ways to the complexities of school restructuring as well as to mathematics and science education. Funding agencies who have invested substantial amounts of money and faith in PIMMS, like United Technologies Corporation, should take pride in its accomplishments. PIMMS is a wise investment in education, community, and the future of Connecticut and America.

The survey instrument was designed to collect descriptive data and, also, to "put some numbers" in the data set. At best the results are mixed. The total population itself was small and subgroups, such as administrators and state department consultants, were too small for simple descriptive statistics. Also, in many instances the subjects in all subgroups chose not to provide a number on the scale of one (low) through four (high). Consequently, the report makes minimal use of the quantitative data collected during the formal interviews. We regret this outcome.

This research was supported by a grant from PIMMS. The study was conducted during the summer of 1995 by the principal evaluator for Curriculum Research and Evaluation. The evaluator expresses appreciation to the following people for their work on this project: Theresa Bruckerhoff, associate researcher and operations manager for Curriculum Research and Evaluation; Joyce Armstrong, documenter; and Katrina Patenaude, documenter. Editorial assistance was provided by Diane Colwyn. John Coy of The Consulting Network; Dan Dolan, Bob Rosenbaum, and Wilma Toney—also known as the PIMMS staff; and Leah Bailey and Ken Green of United Technologies Corporation gave valuable guidance for the study. To the Fellows and all the subjects of this study: Thank you very much.

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Summary

In 1979 a group of ten individuals, concerned about mathematics education in Connecticut, came together to form the Project to Increase Mastery of Mathematics. In 1983-84, the organization was expanded to become PIMMS, the Project to Increase Mastery of Mathematics and Science, with its primary objective being to bring high quality staff development in mathematics and science to teachers of all levels. Its office is located on the campus of Wesleyan University in Middletown, Connecticut. The first cohorts of PIMMS Fellows were high school teachers. Then, for four years the emphasis turned to elementary math teachers and upper elementary science teachers. Currently the focus is middle school teachers. A critical component of the PIMMS Fellows' program is the extension of summer institutes through a variety of outreach efforts. Since 1984, there have been approximately 600 PIMMS Fellows, most of whom continue their involvement in outreach activities. Survey data collected over the years show that the PIMMS Fellows now impact over 20,000 colleagues, administrators, parents, and others each year.

In addition to the Fellows' Programs, PIMMS developed and established other programs to pursue the primary goal of improving teaching and learning of mathematics and science in Connecticut's schools. Several successful programs, like the Institutes, student programs, and various other staff development opportunities, are guaranteed to continue because of the state-wide reputation of PIMMS for excellence, along with the impact of the Fellows. PIMMS strives to serve the needs of teachers and schools in Connecticut by constantly evaluating its effectiveness, identifying new directions, expanding existing programs, and creating new strategies for staff development. PIMMS' success in improving mathematics and science education stems from the strength of its personnel and continually developing programs.

The impact of PIMMS extends beyond its formal programs. The influence of PIMMS is evident throughout the state and the nation by way of the outreach efforts of the Fellows, leadership positions assumed by many participants following their involvement in the program, and project personnel. For instance, PIMMS helped the Five College/Public School Partnership, with headquarters in Amherst, Massachusetts, initiate a program for the professional development of teachers in western Massachusetts. Also, PIMMS, with help from United Technologies Corporation and General Electric, helped start programs in Cleveland, Palm Beach County, and Schenectady. Since its beginning PIMMS has responded to requests from other agencies and institutions for assistance to improve mathematics and science education. PIMMS Fellows and other PIMMS trained teachers are leaders in their school and district curriculum development efforts. Many of these teacher leaders hold key positions in local, state, and national professional organizations. Some serve on editorial boards of professional journals. Many received special recognition for their work as teachers and district leaders.

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PIMMS assisted five College Partnerships to establish PIMMS programs in several eastern states. It works in cooperation with other projects, such as the CT Newspaper in Education Project and the General Electric Summer Institute, to help design programs which meet the particular needs of those involved with improving teaching and learning of mathematics and science. Another component of PIMMS is collaboration and consultation with other successful programs in the state, such as the Connecticut Museum Collaborative, Project for Minority Student Achievement (PMSA), and CT Pre-Engineering Program (CPEP).

Request for Report

In 1995, PIMMS, in collaboration with UTC, requested a study and report that would describe the programs developed and implemented by PIMMS and their impact on teachers' professional development in mathematics and science education in Connecticut. This report used interview data collected during the summer of 1995 and additional supportive material provided by the project itself to document the general findings. The report is focused on the effects of this program intended for professional development of teachers, including their leadership skills, and its contribution to improvement of the mathematics and science climate in Connecticut.

During initial meetings with representatives from UTC, PIMMS, and The Consulting Network, the following questions were developed to guide this study.

Goals and Objectives

- What are the goals and objectives of PIMMS?
- Has PIMMS done what it aimed to do?

Operations

- What is PIMMS currently doing?

Quality and Value

- What is the value of PIMMS to the community?
- What is the value of PIMMS to UTC?
- What does the layperson know about PIMMS?
- Are the intended effects measurable?

Impact

- How have teachers been affected by PIMMS?
- How have students been affected as a result of PIMMS?

Progress

- How is the progress of PIMMS seen by participants?
- What is the next step for PIMMS?

Additionally, the PIMMS staff recommended examination of the following features.

Leadership

- What evidence of leadership was attained by those affected by PIMMS? Categories of leaders are teacher leaders, administrative leaders, program and workshop leaders, college and two-year-college faculty, and those that achieve special recognition by government or professional organizations.

Multiplier Effect

- What characterizes the multiplier effect of PIMMS?

Activities

- What events were organized and presented in local districts, regions, or the state by PIMMS? In particular, describe and review data on the summer program, including the effects of those programs on teachers' classroom practice during the school year.

Climate

- What characterizes the mathematics and science climate in a representative sample of Connecticut communities, with evidence of PIMMS' contribution to an improvement of that climate?

The study used these questions to guide its collection and analysis of data. The report answers these questions, presenting its findings in the light of the above listed categories.

Goals, Objectives, and Principles

From its inception, PIMMS has had one goal which remains essentially unchanged:

> *To improve the teaching and learning of mathematics and science in schools of Connecticut, so that all citizens of the state may understand and appreciate these subjects and have the skills and judgement to use mathematics and science effectively in their daily lives.*

To reach this goal PIMMS formulated the following objectives:

- To serve as catalyst and honest broker so that the importance to a technological society of competence in mathematics and science is understood by decision makers and the public at large, and that successful programs and methodologies are disseminated broadly across the State.

- To mount attractive summer and school year Fellows' programs designed to:

  1. Broaden and deepen Fellows' command of the mathematics and science that they teach and of the whole stream of K-12 curricula;

  2. Familiarize teachers with proposed national standards in mathematics and science;

  3. Demonstrate successful classroom and laboratory strategies and techniques;

  4. Develop teachers' knowledge of, and comfort in, utilizing instructional technologies to enhance teaching and learning;

  5. Encourage interdisciplinary and multi-disciplinary approaches;

  6. Develop skills in teachers to serve as agents of change

  7. Introduce teachers to, and engage them in, a supportive, collegial network in which they operate as responsible professionals; and

  8. Ensure that the program has a "multiplier effect" through the workshops and other staff development activities that Fellows offer.

- To cooperate and collaborate with teachers, administrators, schools, school districts; governmental agencies; business, industry, and private foundations; labor; and civic groups; to help attain our goal.

- To respond to promising suggestions from partners, and to learn from our own experiences, by undertaking new initiatives to the extent that we have human and financial reasons to do so.

Three principles inform PIMMS activities:

- We are a partnership of representatives from education, business, industry, and government.

- We generate a multiplier effect—Once a PIMMS Fellow, always a PIMMS Fellow. The Fellows serve as resource personnel for colleagues in their own or other schools. They reach other teachers through the workshops and many in-service opportunities that they offer.
- We function as a fellowship of persons bound together by our commitment to high quality, useful education for all.

PIMMS' Programs and Approaches

During the year, PIMMS operates programs for teachers and students. Currently, PIMMS is operating eight general types of programs. One is for students—Multiply Your Options Conference. The following seven are for—Middle School Science Fellows' Program, Integrated Mathematics and Science Fellows' Program, Mathematics Technology Institute, Technology Leadership Institute, Technology Leadership Institute Level II, Connecticut Physics Institute, Connecticut Biotechnology Institute, and One-Week Institutes.

Seven approaches serve as organizers for the professional development opportunities provided by PIMMS. A variety of programs have been developed and supported for teachers and students following this model. Six of the seven approaches are:

- **Fellows' Programs:** Two-year programs consisting of four weeks each summer plus academic follow-up meetings. Content, pedagogy, and leadership development are the main components.
- **Technology Programs:** One- to two-week programs engaging teachers in a variety of activities and seminar discussions as they explore new ways to integrate technology into the teaching/learning process for all students. This brings the education of their schools into the "information superhighway" era of the 21st century.

- **Academic Year Programs:** Throughout the academic year, Fellows and other teachers and educational professionals work with colleagues around the state to bring significant new concepts, current applications, and tested teaching methodologies into the classroom. Programs following this approach may take place in various school districts or professional associations and institutes.

- **One-Week Institutes:** Intensive institute programs, highly focused by content and grade-level, for teachers unable to attend the longer Fellows' Program. They are presented at business and educational centers throughout the state, allowing PIMMS to reach many teachers.

- **Student Programs:** For urban high school students plus middle and high school females who are addressing the needs for increased access to math, science, and engineering/technology study and awareness of careers in these fields.

- **Special Programs:** PIMMS-designed programs as a response to specific requests for assistance to meet particular needs of an outside agency or project.

For the coming year, PIMMS plans to continue offering the following programs: Technology Leadership Institute, Middle School Fellows' Program for Science Teachers, Biotechnology Institute, Connecticut High School Physics Institute, Mathematics Technology Institute, Young Scholars Program, and Multiply Your Options Program. In addition, there are plans

to expand the One-Week Institutes and to provide intensive follow-up to the Leadership Institute and the On-Site Program. New programs considered include a Mathmobile Pilot Program, Higher Education: Improvement of Teacher Preparation, On-Site Elementary School Program, and On-Site Professional Staff Development for Middle and High School Teachers. Many of the academic year programs, including reunions, are held in facilities owned by local businesses and industries.

With a few exceptions, the six approaches remain as general organizers for the new programs. The Academic Year Programs will occur in colleges and universities as well as in school districts and professional organizations. A seventh approach has also emerged with following the new development:

- **Follow-Up Programs:** Provide on-going support to previous participants and schools in the continuing reform of mathematics and science education.

Results on Goals, Objectives, and Principles

Interview data collected and analyzed from state department consultants, university professors, school administrators, teachers, and from documents show the manner and extent to which PIMMS is meeting its goal. The data is virtually unanimous that PIMMS plays a pivotal role in promoting significant improvement in the teaching and learning of mathematics and science in the schools. Evidence indicates that teachers and students continue to gain a better understanding and appreciation of these subjects and to develop improved skills to use these areas more effectively.

Information collected over the years and recent interviews with various members of the education community in the state reveal the success PIMMS has and continues to have with meeting its objectives. Due to the state-wide success of PIMMS programs and the outreach activity of the Fellows, there are thriving programs, methodologies, and techniques for the teaching and learning of mathematics and science being applied throughout the state. Teachers, administrators, state department officials, community members, and parents are becoming increasingly aware that, in our technological society, there is a great importance for personal and social development with competence in mathematics and science. Cooperation and collaboration with these individuals and their organizations has enabled PIMMS to bring to the forefront the need to improve mathematics and science education in Connecticut schools.

The Fellows' program has been shown to further teachers' professional knowledge and development, sharpen their skills in teaching, and make significant improvement in their subject knowledge and understanding of instructional technologies. Through their example and their outreach activities, the PIMMS' Fellows encourage and model interdisciplinary and multi-disciplinary approaches. PIMMS has created a continuing and growing network of

friendships and partnerships, enriching Fellows' professional (as well as personal) lives. The latest information, improved classroom skills, connections, and self-confidence make Fellows leaders in education. In this way the multiplier effect has PIMMS Fellows becoming examples for other teachers. As a group, they serve as agents of change in the reform of mathematics and science education in their local districts and across the state.

PIMMS responds to the needs of teachers, school districts, and the community by continuing its programs for more involvement throughout the state. Programs are expanded and follow-up is provided as a matter of course. Through its ongoing evaluation and communication, PIMMS is continually revising and developing programs which meet the needs and recommendations of its "partners" across the state. Interview data collected from teachers and school administrators for this study identified areas of perceived need for furthering the work of PIMMS. In many ways these needs are already being addressed in the new programs developed by PIMMS for the coming year. The interest and awareness of the PIMMS personnel is attuned to the needs of their participants and is evident in the immediate action taken to provide programs to further improve mathematics and science education in the State.

The partnership of individuals and institutions, the fellowship of PIMMS' participants, and the multiplier effect are principles and features that guide the PIMMS programs. The success enjoyed by each program as it follows these principles is recognized by those participants who are involved with and influenced by PIMMS. The goals and objectives of PIMMS are realized through these principles and in the commitment to provide high quality, useful mathematics and science education to all citizens.

In conclusion, results reported here show that PIMMS has realized and will continue to realize its goal and objectives as set forth at the inception of the project. The interview data supplies numerous examples of PIMMS' successes. The project is making very substantial improvements in science and mathematics education within the state by providing effective professional development programs to committed teachers who in turn teach and influence their colleagues.

Other Findings

PIMMS' success is attributed to the effective administration at the different levels of the project's operations:

- The previous Project Director's energy and skill have earned him a very high level of respect. The incoming Director shows promise in providing similar leadership to PIMMS.

- The staff and instructors are recognized for their continued support of school districts, teachers, other involved individuals, and the goals and principles of the project over the years.

- The persistent loyalty of all PIMMS associates (including personnel, college and university professors, Fellows, and participating teachers and administrators) to the project and its mission contribute to the continuity of PIMMS and the future successes.

- The consistently high quality content and operations of PIMMS have increased the potential for success at all levels of schooling.

- The continued financial and in-kind support provided by governmental agencies, business, industry, labor, civic groups, and private foundations have enabled PIMMS to provide high quality programs and services over the years.

General observations include:

- School districts, administrators, and teachers are impressed with the results achieved by PIMMS and continually request further opportunities for their continued involvement in the project.

- PIMMS provides teachers with the skill and confidence necessary to become leaders in the schools, local districts, and throughout the state. Their influence on other teachers, parents, community members, and students is continually increasing, leading to further improvements of mathematics and science education in Connecticut.

1. Introduction

"The commitment to PIMMS is so strong that, if Bob Rosenbaum called us and said—without even explaining the reason—that he needed one of us within an hour, ninety-five percent of the people involved with PIMMS would be there on time."

The Project to Increase Mastery of Mathematics (PIMM) began in 1979 as the joint effort of a diverse group of ten volunteers—individuals from education, business, government, industry, and labor—to foster greater command, understanding, and appreciation of mathematics by graduates of Connecticut schools. The relationship of mathematics and its applications was a central theme of all PIMM undertakings.

In 1983, the organization broadened its scope to include science (and changed its acronym to PIMMS) and, at the same time, expanded its activities by mounting a Fellows' Program. PIMMS continued to expand its offerings over the next twelve years by including middle and elementary school teachers in the Fellow's Program, developing Institutes and On-Site Programs, assisting with student programs, and working with other institutions and agencies to improve mathematics and science education.

After many years of work, expansion, evaluation of the project, and maintaining a large array of funding sources, PIMMS was interested in obtaining long-term corporate funding. This would both provide security for its ongoing operations and stimulate interest in governmental grants, thereby allowing PIMMS to further expand its operations and reach greater numbers of teachers throughout the state. United Technologies Corporation, serving as the primary corporate funding source over the past four years, has enabled PIMMS to strengthen its position in order to maintain and develop successful programs, to support teachers' attendance at its programs, and to add a paid full-time Director of Mathematics. This person is now the Director of PIMMS. The founding Director, who served for fifteen years as an unpaid volunteer, continues as the Chair of PIMMS.

Now, to represent itself fairly and help secure continued funding at an appropriate level over the next four years, PIMMS formally presents this report. The report displays the effectiveness of its programs for improving the professional development of mathematics and science teachers and the overall quality of education in Connecticut. PIMMS, in collaboration with UTC, solicited this formal report describing and analyzing the effects of the project.

The report to follow supports the effectiveness of PIMMS based on interviews with participants and a review of documents compiled over the years by the PIMMS personnel. The remainder of this section describes PIMMS in general terms and outlines the purposes of this report.

Overview of PIMMS

PIMMS was founded by Robert A. Rosenbaum, its present Chairman, in collaboration with other individuals highly concerned about the education of children in the fields of mathematics and science. Since 1979, when it was first created, through 1983, when it was expanded, to the present, PIMMS has become a professional organization for the development of innovative curriculum and instruction in science and mathematics. Over the years PIMMS has continued as a partnership between individuals and organizations who provide in-kind contributions, volunteer hours, and financial support for its operations.

The central features of the PIMMS concept are the generation of the multiplier-effect through the outreach efforts or field-work of the Fellows and the impact on teachers and school districts by its many programs. Correlated with the multiplier-effect is the high level of leadership attained by the men and women served by PIMMS. PIMMS reaches thousands of teachers each year through professional development programs, workshops, consultative assistance, and collegial discussions of curricular, pedagogical, and subject matter problems. Many of those involved continue to expand their professional horizons, becoming district leaders in the areas of math and science, school administrators, leaders in programs and workshops, leaders in the professional organizations, and award winners. PIMMS, with its many related components, continues to have a significant impact on mathematics and science education in Connecticut.

Initially, PIMMS expanded its activities by piloting a Fellows' Program for high school math and science teachers. The emphasis shifted over the years to include middle and elementary school teachers. To date, 600 teachers have been served by this program. PIMMS continues its commitment to mathematics and science education through additional programs designed to improve teaching and learning, which include various Institutes, On-Site Programs, College Bound Program, and the Dana Problem Seminar, serving approximately 2,702 teachers thus far. The Young Scholars Program and Multiply Your Options Conference, hosted by PIMMS, have had a direct impacted on approximately 5,000 students. In addition, the PIMMS' personnel, Fellows, and others affected by PIMMS have been directly involved in the planning and implementation of several major curriculum and professional development projects and have collaborated with, or offered advice and support to, others.

New directions for PIMMS are constantly evolving as the project responds to the continually emerging needs of schools and teachers. Through its programs, PIMMS has directly affected almost 2,500 teachers since 1984. The formal and informal outreach activities of these teachers has influenced thousands of other teachers in the state.

When the project began its budget was minuscule. As the project has grown and expanded, the annual budget has increased, including in-kind contributions and volunteer hours, to more than one million dollars. Major financial support over the years has been provided by the Connecticut Department of Education, Connecticut Department of Higher Education, Charles E. Culpeper Foundation, General Electric Foundation, GTE, United Technologies

Corporation, and Wesleyan University. Substantial contributions have also been made by Aetna Life and Casualty Foundation, Amax Foundation, Chesebrough Ponds, Choate Rosemary Hall, CIGNA, Connecticut Academy of Science and Engineering, General Signal, Edward W. Hazen Foundation, Northeast Utilities, Omega Group, Perkin-Elmer, Pfizer Inc., Pitney-Bowes, Raymond Engineering, Schlumberger-Doll Research, SNET, Stanley Works, Union Carbide Corporation, and the Xerox Foundation.

Existing Programs

Currently, PIMMS offers twenty-five programs (including all duplicate types) to 760 participants. The programs for 1995 are: four Fellows' Programs, two Technology Institutes, four Academic Year Programs, and fifteen One-Week Institutes. The total operating budget for the year, including in-kind support, is $1,300,000, with funds provided by two NSF grants, five Dwight D. Eisenhower grants, local district support for participants, and contributions from businesses, foundations, and others. As a result of long-term investment by UTC over the past four years, PIMMS has been able to leverage substantial funds from other sources. In addition, the project was able to hire full time directors in its mathematics and science programs; maintain, expand, and develop the programs that are offered; and support teachers to attend the current programs.

Future Plans and Programs

At this time PIMMS is celebrating its fifteenth year of operation. All indications point to a continuing need for its services to education. The primary elements for maintaining and increasing the work of PIMMS are to expand current programs and to develop new programs in order to meet the needs of math and science teachers throughout the state. Developments in the past two years include the Integrated Mathematics and Science Fellows' Program for elementary school teachers; One-Week Institutes expanding the services to more teachers, especially those unable to participate in the longer summer programs; and the Technology Leadership Institute Level II providing advanced staff development to those already demonstrating some knowledge of technology, especially in the use of electronic telecommunications. As with other PIMMS programs, participants must be willing to assume leadership roles in their districts by assisting and consulting with others on the use of technology and in the further development of curricular and pedagogical knowledge and skills. As more teachers participate and become involved with the outreach work, PIMMS' impact on mathematics and science education in Connecticut will become greater.

To maintain its success in the future, PIMMS is required to continually review its existing programs, survey teachers and administrators to identify new directions, and develop new programs to better serve their needs. Plans for the next four years include maintaining successful on-going programs, expanding programs to meet the needs of additional teachers,

and developing new projects to meet currently unmet needs.

Programs slated for expansion during the next few years are:

- **The One-Week Institute:** Expansion of the One-Week Summer Institutes held during the summer and designed to meet the expressed content and grade-level-specific needs of teachers. This program will offer about fifteen to twenty mathematics and science workshops to teachers in grades K-12 during the school year.

- **Four-day Extensive Follow-Up, Leadership Institute:** Four-day intensive workshop held during the summer for all interested PIMMS Fellows teaching math and/or science in grades K-12. This extends the three-day session currently held during the school year for only the most recent PIMMS Fellows. The focus will include introducing new mathematics and science content, using new technology, building leadership skills, and also seminars on new assessment practices.

- **Follow-Up to On-Site Program:** Provide on-going support to schools involved in the 1992-1994 On-Site In-service Program in their continuing reform of mathematics and science programs that they have begun. Included in this program will be a series of workshops on new topics; specific assistance to staff members as needed; the initiation of dialogues between mathematics and science staff in order to develop effective means of integrating these areas; and exploration of the ways in which mathematics and science departments can be more responsive to the needs of students who are interested in careers in technology fields.

As noted above, PIMMS plans to develop and establish new programs over the next few years. The four new programs are:

- **Mathmobile Pilot Program:** In the development stage during the past several years, this program pilots a prototype model of a math van or truck to visit schools.

- **Higher Education, Improvement of Teacher Education:** Initially a modest program of workshops for college teachers, school and college administrators, and school boards which will be expanded as needs become more apparent. The future of this program could help to bring the structure and content of teacher preparation, mathematics/science programs, and teacher licensure provisions into alignment with twenty-first century needs.

- **On-Site Elementary School Program:** Continuing professional development on site for elementary teachers. The PIMMS staff will work with teachers and administrators to design workshops in mathematics and science which focus on the expressed needs

of the staff in the district. Before proceeding, this program will require firm commitments for participation from the school district and teachers.

- **On-Site Professional Staff Development (Middle and High School)**—A staff development program that focuses on the specific content and instructional needs of the district. Only for those districts making a firm commitment to involve both middle school and high school teachers. A concentrated effort to help teachers work together and integrate materials from various content areas will be promoted through the addition of language arts and social studies staff to the On-Site teams. The goal is for team members to provide teachers with model lessons and demonstrations of effective integration at both the middle and high school levels.

Purpose and Organization of the Report

This report focuses on the impact PIMMS has had on people and institutions involved directly or indirectly with science and mathematics education in Connecticut. It describes common experiences among teachers and across school districts. It develops themes that signify PIMMS' impact and its successes in achieving the goal, objectives, and principles which define the project. The remainder of the report is organized as follows. Section 2 describes the data collection methods. Section 3 discusses the needs for the project. Section 4 presents the findings. Section 5 develops the themes and conclusions of the study. The final section provides recommendations for sustaining and increasing the effects of the project. The appendix contains references, biographical sketches, and survey instruments.

2. Analysis of Data and Methodology

This section describes the study in terms of the criteria and procedures for collection and analysis of data.

Criteria

This report reflects the accomplishments of PIMMS as defined by the goal, objectives, and principles of the project. The first step for the study was to establish criteria by which to identify and describe the effects. This process included several weeks of reviewing the projects' objectives, identifying the program's operations, and consulting with PIMMS personnel and the external evaluator on what information was relevant to the report. Based on the information received, questions were developed for a formal interview instrument to elicit relevant data from individuals who either participated in the PIMMS' programs or observed its effects.

The focus of the interview questions included PIMMS' impact on: teachers' knowledge and skill, student achievement, curriculum and instruction, parent and community understanding of the importance of mathematics and science education, college and university teacher preparation programs, individuals involved in the project, and the state department functions. The following issues were also examined:

- What does PIMMS claim to do for teachers and students?
- Is PIMMS achieving the results that are promised? How? To what extent?
- How are results measured? Are they reasonable, reliable, relevant to the goal?
- Is PIMMS administered effectively at all levels of operation?

The study analyzed data from three sources. Formal interview data was collected over the phone from a representative sample of randomly selected individuals associated with PIMMS and involved in different aspects of mathematics and science education in the state. Supplementary data was obtained informally over the phone from selected individuals who were either directly influenced by, or had a direct influence on, specific PIMMS programs. Additional data was collected from documents provided by the PIMMS personnel. Each data set was analyzed and integrated into the section on findings.

Data Collection

The main sources of data were formal and informal phone interviews with different individuals during the summer of 1995. Three documenters completed a total of sixty formal interviews during a one month period from mid-July through mid-August. Initial contact with the randomly selected subjects was made by the PIMMS staff, who sent each of the sixty subjects a letter defining the purpose of the interview, the procedures, and a copy of the survey questions. The sample group consisted of three state department consultants, six university professors, fourteen school administrators, and thirty-seven classroom teachers. Within a few days after the initial mailing, each field worker contacted the assigned twenty subjects and established a convenient time to conduct the formal phone survey. Since most schools were on summer recess at the time, it was not possible to reach all the subjects originally selected for the study. Those subjects who could not be reached were eliminated from the original sample group and a new, randomly selected subject was contacted instead, thus maintaining the integrity of the design.

At the agreed upon time, each subject was telephoned and the formal survey process began with the documenter asking and clarifying each question. The documenters wrote verbatim or summary notes on the answers given by the subjects. The documenters' notes were collected and analyzed. The length of interviews varied by subject, with some sessions lasting a short time, while others continued for over an hour. In a few cases subjects also supplied written responses to the survey questions. Every subject willingly participated in the study. No one refused. After completing twenty formal interviews, each of the three documenters prepared the data for analysis in a separate formal report. An outline established by the evaluator served as the organizer. Quantitative data from each group was calculated and analyzed. Qualitative data was summarized and analyzed. Themes were identified and recommendations that are grounded in the data were written in order to increase the impact of PIMMS. The three documenter's reports were submitted to this evaluator for final analysis.
Additional informal survey data was obtained from individuals recommended as subjects by the PIMMS staff. This material, in addition to important and relevant details from the PIMMS documents, was integrated into the findings of the formal survey. The integration of these three data sources makes up the findings in this report.

Initially, the findings were to focus on and compare data supplied by each group of individuals selected for the study (for example, administrators and teachers). With some details and descriptions this was possible and relevant, but for the most part comparative data was unavailable or not applicable to the needs of the report. Two reasons for this result are the limited number of subjects participating and the fact that many subjects from the different

groups had similar responses, since they were PIMMS Fellows who had changed groups (i.e., teachers who became administrators) over the years. Responses to the formal interview questions from most subjects overlapped, which made clear-cut distinctions implausible if not impossible.

The final product is a detailed descriptive report of PIMMS and its impact. Themes are discussed, conclusions reported, and recommendations offered for sustaining and increasing the programs' effectiveness.

3. Challenge for PIMMS

In 1979, PIMM was founded to help improve the learning of mathematics for those going into the work-force or on to further education. In 1983, the scope of the emphasis was enlarged to include science. During the early years of PIMMS, while reflecting on the steadily deteriorated health of our society, the Director said, "We often felt frustrated by the enormity of our problems and by the forces and inertia arrayed against us." He said he "feared" but, at the same time, was prepared to accept that PIMMS would "have to be satisfied with merely slowing the decline of our schools' measurable performance."

As the program grew, the Director said, "I came to know the teachers who worked as PIMMS Fellows; I realized that there are tremendous resources in our schools ready to be mobilized." The multiplier effect of PIMMS "is a rising tide that helps to raise all boats:....PIMMS Fellows are already making substantial changes in the schools of Connecticut" He said their work, along with the impact of the additional programs directed and supported by PIMMS, is helping "education return to its rightful place as the engine of progress of a healthy society." The results of this study bear testimony to the wisdom and truth of his words.

As the conditions of American society in some sectors show little improvement and the conditions of many schools show the effects of continuing social and economic problems, PIMMS retains its central goal to improve mathematics and science education in Connecticut. The successful pursuit of positive change in mathematics and science education is the constant challenge of PIMMS. Consistent growth in response to the increasing and changing needs of the schools keeps teachers involved and enthusiastic about the opportunities available through PIMMS. Their motto, "Once a PIMMS Fellow, always a PIMMS Fellow," gives energy to the multiplier effect and a promise to keep the mission of PIMMS alive, active, and effective for many years to come.

4. Findings

This section describes the effects of PIMMS across several main areas of interest, including teachers, students, schools and school districts, communities, colleges and universities, individuals, and the state of Connecticut.

Teachers

Many teachers, especially in the elementary levels, have very little substantive knowledge in science or math. In the upper levels the knowledge is often out-of-date. Teaching techniques reflect these gaps. Without exception, PIMMS improved or expanded teachers' knowledge and use of process-oriented instruction in science and mathematics. Teachers, administrators, university professors, and state department consultants reported the impact of the PIMMS experience in these areas to be very high. All of the teachers interviewed had made some changes in both the area of content and the method of teaching. The amount of change ranged from reinforcing and expanding what was already being done to completely revolutionizing the whole teaching style. Most teachers indicated that their experiences with PIMMS gave them the courage to make these changes.

The data collected for this study describes improvements in subject matter understanding, methods of teaching, use of materials and resources, purpose of teaching, and extended role of a professional teacher. Teachers said they are excited by the opportunity to do an intense study of their subject area. This enthusiasm is especially true of elementary school teachers who previously studied no more math or science than what they were expected to teach their students. The intense study increased teachers' awareness of the variety of concepts within a subject area. Math teachers were able to see the importance of probability, statistics, and geometry for improved understanding and, as a result, restructured their curriculums and instructional plans to reflect these concepts. High school science teachers incorporated a greater variety of content into their instructional plans. Inclusion of biotechnology is an example. As one high school science teacher in Meriden said, "PIMMS is where I learned the content of my subject".

During PIMMS training, each teacher is required to teach a sample lesson for both practice and analysis to the other in the group of PIMMS trainees. Following each session, the group critiques the lesson and provides ideas and examples to improve the presenter's methods of instruction. Even though many teachers are initially uneasy with this process of peer instruction and critique, upon reflection they said it provides them with improved abilities and increased self-confidence. Additional comments about this process and similar modeling experiences are:

"This was the best experience I ever had. I will never be a paper and pencil teacher again. I knew what good teaching was, I just didn't know how to do it until PIMMS. PIMMS made a lot of teachers better, but it made me into a real teacher."

The excitement about teaching encouraged elementary teachers actually to teach mathematics rather than merely use it to sustain a fifty minute quiet period after lunch. Teachers now use mathematics as facilitators of knowledge, incorporating hands-on approaches that excite students, making them active participants in the classroom. Also, teachers are using integrated units, rather than isolated topics, and making connections among math, science, and other curriculum areas. For the first time in their careers, real higher level teaching and problem solving is the instructional focus for many of these teachers.

The new focus for mathematics and science curriculum also contributes to changes in classrooms. The range of changes includes removal of all desks to make room for tables at which students work together on projects cooperatively to increased use of advanced technology and other resource material. Teachers said that after PIMMS training they understood the purpose and process for using manipulatives, various resources, and current technology in the classroom to improve instruction and content development. Some teachers studied and learned to use tools, such as the graphing calculator, which they themselves would not previously use as a teaching tool at their grade level, but would instead prepare their students to use for solving mathematical problems in their later years. Upon their return from PIMMS training, some teachers became the technology facilitators in their buildings. As an example, one high school science teacher in Meriden, who knew very little about advanced technology before PIMMS, is now known as the "tech czar" of the Connecticut Association of Physics Teachers (CAPT).

Most teachers who attended PIMMS Institutes said that, as a result of the intensive experience, they gained much needed expertise in their subject. They internalized the PIMMS model and have renewed energy for teaching. Many teachers improved themselves in the topical areas they felt were their weakest topics and now do things they never before imagined doing, such as reading professional and academic journals, attending conferences, and serving as building and district resource people. As a result of PIMMS, these teachers acquired a progressive vision of education and are more assertive, committed, and involved in the profession. The PIMMS Fellows are known as advocates for positive change in Connecticut.

Survey data show that all individuals interviewed agree that PIMMS has been instrumental in improving teachers' content area knowledge and skill. Scores ranged between three and four on the four point scale, with four being the highest score.

Students

Teachers and administrators reported that PIMMS has had an impact on student achievement. For the most part this impact has been measured subjectively (however, see the sections on Montville and Stratford below). Improvement is most often identified by increased levels of students' motivation and enthusiasm, by selection of courses and activities, and through informal measures of achievement, such as teacher-made tests. In most cases, teachers place a greater importance on the improvement of students' attitudes about school in general and mathematics and science in particular. In the teachers' opinion, unless students' attitudes change in a positive direction, the hard achievement data will not change. Teachers commented on the pervasive apathy towards academic study in American society. They believe the individual student's positive motivation to be an active participant is essential to realizing achievement gains that are consistent with one's capability. Furthermore, the teachers said that PIMMS has had a positive impact on their efforts to change students' attitudes. Math and science are becoming favorite subjects, and some students are concerned if they are absent and miss something that was covered in class. Hence, the teachers' new-found excitement with mathematics and science is conveyed to the students who are "moaning" less and finding these subjects to be fun, interesting, and relevant.

In support of these assertions, teachers and administrators pointed to students' increased involvement in mathematics and science courses and activities. In some high schools, students select higher level, more rigorous courses. The after-school science clubs at many elementary schools are experiencing increased enrollment. In Danbury, a PIMMS Fellow organized a science fair in his school, and it became an annual event with more participants and better quality entries each year. Meriden sponsors an annual district-wide Math Olympics competition. At Meriden's third, fourth, and fifth grade school, where a number of PIMMS Fellows hold teaching and administrative positions, they always placed first or second in the district. The fourth grade has never been defeated. Teachers report that their students are better problem solvers and believe students are increasing their math knowledge. From most accounts students are now better able to use the appropriate vocabulary and concepts as they complete activities or solve problems. This result is an increased benefit to students who already demonstrate high levels of achievement in math and science. An administrator in New Britain noted that graduating seniors, who have gone on to prestigious universities like Harvard and MIT, took courses with a number of PIMMS Fellows.

According to some teachers, their own classroom assessments show increases in student achievement. One Danbury middle school teacher uses her comparative assessment tool and reports general improvement since PIMMS. Another Danbury teacher changed his assessment procedures in order to gather a daily measure of students' understanding. His data shows continual increases. Most teachers report using some kind of assessment where the results show students' achievement is improving. However, one high school teacher said she is concerned that she is not seeing much evidence of higher level thinking. Also, some

parents express concern about the students' grasp of basic math skills. Some teachers see basic math skills as secondary to problem solving and push these concerns aside.

Most teachers said the only objective measure of achievement is a comparison of standardized test scores of students tracked on a long-term basis. They gave various reasons for not providing these scores as evidence of achievement. For instance, they said that, because standardized testing in science does not occur until middle school, teachers do not know or are not interested in standardized achievement data, and that some students' achievement is not accurately reflected by quantified assessment measures. A few teachers indicated that the test scores in their districts are still low and do not show signs of improving. Some teachers reported increases in standardized math scores in their districts, but the percentages were unavailable. In Danbury a seventh grade teacher compared her class to other classes in her building and discovered that her classes had an overall higher mean score and were scoring a few percentage points higher on the Connecticut Mastery Test (CMT). Objective evidence of increases in students' achievement was most apparent in a Meriden third, fourth, and fifth grade school that once had the lowest math scores on the CMT of all the urban schools. Two years after the PIMMS training, these scores rose to the second highest of all the urban schools. Meriden has maintained this accomplishment for more than two years.

The quantitative survey data was difficult to analyze on this question: Is PIMMS producing more able students? While quantitative responses to this question were at the 3.5 level or higher and some individuals reported a higher percentage of students passing the Connecticut Mastery Test, approximately 75 percent of the teachers and administrators interviewed chose not to respond with a numerical value. They cited lack of hard data or noted that there are too many factors that influence students' achievement.

Schools and School Districts

PIMMS is promoting constructive curricular change to expand its effective elements, eliminate the ineffective, and introduce new content and instructional methods that incorporate the best research findings available. Teachers and school administrators report that curriculum committees throughout the state use the content and instructional standards modeled by the PIMMS staff to revise math and science programs. District, school, and classroom curriculum revisions have occurred in every case after a teacher or group of teachers participated in the PIMMS program. The impact on some teachers was so significant that they changed their entire instructional design. Other teachers said that to make a complete change immediately would be too overwhelming and opted instead for the process of making slower and more deliberate changes. This latter approach is favored by a university professor who expressed concern about teachers and programs whose response to current trends overlooks tried and proven methods or materials.

The philosophy and techniques encouraged by the PIMMS staff provide guidance for many current curriculum reform projects throughout the state. Often PIMMS Fellows are the initiators of curriculum reform in their districts and schools and are the key players in these. As a result, current curriculum plans in all districts served by PIMMS are outgrowths of the PIMMS program. The *Curriculum and Evaluation Standards for Mathematics* adopted by the National Council of Teachers of Mathematics is the basis for the mathematics curriculum. The instructional approach in both mathematics and science is process-oriented and activity based. A unit approach is preferred over the more traditional textbook-driven plans. Assessment procedures are being changed to reflect the new focus on authentic achievement (see Newmann, Secada, and Wehlage 1995).

PIMMS has given teachers the courage both to propose and advance these reforms. The positive reputation of PIMMS, in general, and the Fellows, in particular, persuades school administrators to support these innovations. According to one school administrator, "it was these types of initiatives which led to our school being selected as a Blue Ribbon School in 1993, quite an accomplishment for an urban school." In a Meriden middle school, a PIMMS Fellow is primarily responsible for the establishment of a program for girls interested in math and science. In New Britain, an administrator who is hiring a math/science resource person for a new magnet school is searching specifically for a PIMMS Fellow. PIMMS regularly receives calls from district administrators requesting information on Fellows who might be interested in new positions. Administrators want to hire PIMMS Fellows. The PIMMS-trained teachers are constantly engaged in developing more effective math and science programs for their districts and buildings.

The instructional plans developed by PIMMS-trained classroom teachers reflect the impact PIMMS has on a school's curriculum. These teachers revise and enact district reforms and are models of good teaching for other teachers. In most classrooms, performance has become the basis of assessment. Teachers have ceased to be test- and grade-driven and instead have encouraged students to be active, confident participants in the learning process. Reality-based math and science and the use of technology are now the bases for curriculum and instructional development. Spiralling techniques are implemented in many classrooms and districts. Math teachers focus on geometry, data gathering, and statistics earlier in the year and establish these concepts as reference points for future instruction. Science instruction proceeds at all levels from concrete to abstract. This method extends across the curriculum and is more comprehensive than in the past. The Shelton School District, piloting a new format from PIMMS, completed a needs assessment for the district before revising its math and science curriculum. A word of caution came from a school administrator in Fairfield, who said that PIMMS and other programs must be careful not to force (unknowingly) elementary school teachers, who are by design multi-subject teachers, to departmentalize. A needs assessment design similar to that done in Shelton would recognize the district's desires and, at the same, time recommend a program that maintains the integrity of the curriculum and school organization.

By far, the most pervasive change in curriculum is the increased use of manipulatives to introduce concepts in the upper levels and to introduce content at the lower levels. In Shelton, paper and pencil exercises and textbook instruction at the primary level were completely replaced by use of manipulatives. In some elementary schools in Danbury and Meriden, concepts in mathematics and science are introduced and developed with manipulatives. A good understanding of physical properties is required before progressing to more abstract areas. Math teachers at different levels have incorporated manipulatives as fundamental teaching tools. In Meriden, the PIMMS Fellows working on the district curriculum development team incorporated manipulatives into the new math curriculum. Other improvements of district, school, and classroom math and science curriculum and instruction as a result of PIMMS include cooperative learning, discussion groups, writing activities, advanced resources, hands-on activities and experiments, and real life higher level problem solving.

In many schools, computers and calculators have become instructional tools of choice in math and science. The use of calculators for learning mathematics and solving problems, including the graphing calculator at the high school level, was explored by many of the teachers in various PIMMS programs. An administrator in New Britain said, "For the first time teachers really understand how to use these items in their classrooms in order to improve instruction and learning. Now they want to have them available and incorporated into the school curriculum." The same result is true of computer use in the classroom. In a New Britain fifth grade class, the PIMMS teacher purchased a phone line to connect the computer to the America On Line system. In Meriden a PIMMS Fellow obtained a grant to purchase computers and CD-ROMs for the elementary school. She then proceeded to train all the teachers how to use this equipment, further expanding the outreach of PIMMS modeling. Teachers' training and increased use of technology occur in districts around the state.

PIMMS provides teachers with collections of ideas for developing hands-on, integrated activities in their classrooms. In Shelton, a district that has no PIMMS Fellows, Ralph Yulo gave a science workshop demonstrating activities and processes appropriate for the instructional needs of the district. Most of this material has been incorporated into classroom curriculums. Mari Muri and Steve Leinwand did workshops that encouraged teachers to develop integrated activity-based lessons and units for their students. Changes in classroom curriculums, program options, and student connections have occurred as a result of these new methods of instruction and planning. A middle school teacher in Meriden now ends each marking period with an integrated project assessing the students' real knowledge of concepts studied during the quarter. A fifth grade teacher in New Britain organized an after school science club for students interested in furthering their active exploration of science concepts. A high school teacher in Meriden and his students have joined a fifth grade teacher and her students for a number of different projects during the year, including a laser activity involving the study of lenses. This cooperative venture is so successful that the district is

developing a district-wide activity based on this model.

The range of units and activities developed by PIMMS Fellows at all levels is extensive. High schools attempt to integrate algebra, trigonometry, geometry, and physics. High school teachers do more hands-on work with geometry and measurement. Exposure to PIMMS concepts and resources led to the purchase of a rock tumbler to be used for units on minerals, increased emphasis on estimation, percents, and algebra using such things as algebra tiles and pattern blocks, and more in-depth science units on topics such as magnets. Students used integrated science and math topics to create proportionally accurate models of animals and insects out of cardboard and plywood. They also made boomerangs, mousetraps, cars, barges, and electronic radios. First grade teachers created eight backpack kits consisting of integrated math and language arts activities for students to take home and do with their families. A middle school teacher created hands-on packets of physical science activities for elementary school teachers who are weak in this area. Active cooperative learning and planning between students and teachers is evident in all of the activities developed by PIMMS Fellows.

In most classrooms the instructional focus after PIMMS training concerns teaching integrated concepts and applying them to everyday activities. Examples include graphing sports and weather statistics reported in newspapers, such as *USA Today*; using nutritional labels on cereal boxes to compute, compare, and study nutritional needs; and applying mathematical concepts and strategies in a unit on comparison shopping with coupons. Three particularly innovative activities were developed by middle school math teachers in Danbury. In one integrated math activity on quilting, students studied different geometric shapes, rotations, areas, perimeters, and percents. At the end of the unit they each designed and stitched their own quilt square, which served as the unit review. Students in this same class participated in a statistics project where one half of them adopted a special interest cause while the remaining students adopted opposite positions. With the same sets of statistics, students created posters, statistical graphs, and material to support their positions. After classroom presentations, the students compared and discussed the accuracy of statistical information and its ability to support different positions, thereby misleading the public. In another middle school math class, students created origami frogs that actually jumped. The students held a Frog Olympics by first building, to scale, a model of the ancient Olympic stadium. After all the events were completed, they computed the averages for records and distributed prize ribbons. In addition to exciting students about math and improving their competence with these skills, the PIMMS Fellow who developed this unit also won a teaching award.

Teachers and university professors gave high marks (range was 3.4 - 3.75) in response to the question: Has PIMMS improved curriculum and instruction? A low score (3) was reported by a state department consultant, who explained that "strong PIMMS Fellows contribute to radical change; however, lack of support for change in the district has hampered some Fellows." Some of the inconsistency with the implementation of PIMMS programs across districts is explained by different strengths of the individual teachers and varying local

circumstances. Money, time, and resistance from "entrenched, traditional teachers" are cited as the main negative factors.

Communities

Parents constitute the largest group of community members that is aware of the PIMMS program. Some of these individuals are made aware of PIMMS by their children's classroom teachers or by a principal. Another small group of parents is aware of the PIMMS Fellows, but not the program itself. These teachers, whom the parents know so well, are usually the most respected math and science teachers in the schools. Many are appointed by principals to serve as building leaders, and parents know that, if they have any questions or want something done in the areas of math or science, the best contact person is the PIMMS Fellow. Also, PIMMS Fellows are often the teachers who are directly responsible for, or involved with, Family Math and Family Science Programs.

A majority of parents is not actually aware of PIMMS, but does know that changes have occurred, or are occurring, in the math and science curriculums. Most parents are responsive to these changes. They are interested, supportive, and involved. Parents generally trust teachers to make the best educational decisions, as long as these changes lead to effective learning opportunities. In Danbury, the Parent and Teacher Organization in one school provides materials and resources to the science and math teachers, covers out-of-pocket expenses for activities and units, funds grants for teachers, and solicits their own grant funds to support initiatives in science and math. There are parents who have difficulty accepting the new focuses in these areas, but, after speaking with teachers, observing classes, or participating in sample activities like those done on the Parents Day in Danbury, the parents' attitudes improve. The one question that most parents raise about school initiatives is: What will be the impact on CMT scores?

Other community members seem to be minimally aware of curriculum development projects. One teacher said he had noticed a more positive relationship between the schools and the community and that PIMMS may be one of many reasons for this development. Administrators in Shelton, Meriden, and Fairfield indicated that there is some community awareness of PIMMS and of PIMMS initiatives in their districts. In Fairfield the PIMMS in-service program was the first in the district, and the first of its kind in any middle school, which made for significant press coverage and community involvement. Shelton and Meriden have both solicited local corporate support for equipment and school activities. After the PIMMS experience in Shelton, teachers put pressure on the administration to purchase equipment and materials. Administrators sought support from the local community. Similarly, Meriden's school administrators solicited support for their district's Math Olympic Competition. To increase community awareness, they invited a variety of community members to moderate the events.

Nonetheless, some teachers reported that the efforts to foster community awareness impact too few citizens. Over one-half stated that their community was unaware of, or uninterested in, PIMMS and its ideas for the development of math and science in the schools.

Teachers and administrators agreed that PIMMS has this positive impact on the community—its philosophies and curriculum designs develop better future leaders and scholars. The students who graduate from schools whose curriculums have been substantially developed or influenced by PIMMS will be better able to work together, to think, and to solve problems. They will be better prepared to use current technology, to meet the standards expected by the private sector, and be better workers. These values and capabilities are assets that benefit industry, schools, and society.

Quantitative data was mixed in response to the question: Has PIMMS improved parent, adults, and family relations in schools? State department consultants and school administrators tended to give low scores (averages of 2 and 2.6 respectively). Teachers gave high scores (average of 3.5). However, teachers were quick to qualify their high numbers with admissions that, for example, during open house nights and workshops, there were too few parents present. Everyone agreed that Family Math and Family Science nights were hits with parents. Administrators and state department consultants indicated that, due to the demands of their jobs, they may be more in tune with community members than the teachers.

In recognition of the difficulty of representing a project's affect on a community quantitatively, we prepared vignettes on Montville and Stratford. The vignettes are representations of the impact of PIMMS on different kinds of districts, emphasizing its success with improving mathematics and science education over an extended period of time. Teachers and school administrators from these districts were among the first PIMMS Fellows in the early 1980's. Since then, their association with PIMMS has continued uninterrupted. The leadership roles they assumed, their professional commitment, and influence promoted the PIMMS' philosophy and techniques in Montville and Stratford.

The subjects responded to the following items during extended telephone interviews:

- Briefly describe the community.
- Explain the history of PIMMS' involvement with your school district.
- What impact has PIMMS had on your district?
- Describe leadership in mathematics and science by people who were involved with PIMMS.
- Describe changes in the professional climate in the district as a result of PIMMS.

- Describe the effects on students' formal and informal achievement; attitudes; academic choices; college plans; career decisions.
- How has PIMMS influenced parents? Advisory Board? Family Math and Family Science?
- Has a new level of community pride emerged as a result of PIMMS?
- Describe two factors that have the greatest influence on PIMMS' success or failure.
- What does your community need next from PIMMS?

Montville

Montville is a blue-collar suburban community of approximately 17,000 residents located midway between New London and Norwich. The population is primarily white with most people working at EB (Electric Boat) or the Casino. The minority population is at about 8 percent. The current trend to more accurately identify Native American Indians is expected to impact on this figure in the near future. The per pupil funding is relatively high in terms of the per capita income. There are approximately 600 students in the high school, 75 percent of whom go on to college.

The current elementary math supervisor in Montville was a member of the Priority School District—Connecticut Association of Urban Superintendents class of Fellows in 1989-90. The high school math department chair was a PIMMS Fellow during the second summer of the program. Leadership positions obtained by both of these teachers coincided with their PIMMS' training. Their involvement in PIMMS spans the last ten or eleven years. The PIMMS philosophy and techniques have directly or indirectly affected their every curriculum and staff decision. The district continues to be very supportive of the work of PIMMS and recognizes its impact on mathematics and science. Together these administrators have sent, recommended, and encouraged a number of teachers in the district to become involved with PIMMS through its ancillary programs, institutes, and the Fellows' program. Currently there are three additional PIMMS Fellows in the district, two at the elementary level and one at the high school. These Fellows are the educational leaders in mathematics at their levels, influencing the work of their colleagues and, in turn, most students.

What follows is a sketch of Montville's PIMMS program composed of quotes from the subjects:

> "*Since the first exposure to PIMMS in 1984, it has always directly or indirectly impacted everything we do in math and science in Montville. Montville would not have been able to attain the level of achievement and success in mathematics it has*

without the direct influence of PIMMS. The involvement of PIMMS in the district continues to be strong even after all these years. The PIMMS personnel are always available to answer any questions, provide any resources or services, and make any connections necessary to meet the needs of our district. PIMMS always responds to our needs and publicly recognizes our accomplishments. For example, Montville currently has a very gifted math student performing at a level which far surpasses what the district is able to offer him at this point. Bob Rosenbaum, Chairman of PIMMS and previous Director, has agreed to serve as a mentor for this student.

Our only regret is that the training program for Fellows only lasts two summers. We could go for more training every summer. Our levels of professional development and our math and science curriculums are directly attributed to PIMMS and its influence on the teaching staff. The caliber of instructors in the PIMMS project is higher than any other staff development program. PIMMS training makes teachers want to reach for the stars. They are driven to succeed. The mathematics chair in the high school has recently hired a number of progressive math teachers who have the qualities recognized by PIMMS. One designed a teaching unit with a home economics teacher from East Lyme. With the use of graphing calculators and computer technology, the geometry students designed quilt squares for the home economics students who used the patterns to create a quilt. This process involved a great deal of cooperative work between the two sets of students as they revised and reworked the patterns to meet the needs of the quilters. The technology used by the geometry students was available in the high school because of the aggressive funds solicited by the department chair and awarded, in part, because of the connection Montville maintains with PIMMS.

The PIMMS Fellows in the district present workshops and staff development training to their colleagues and encourage curriculum changes. In addition, they have attended and presented workshops on local, state, and national levels. Recently a teacher presented in Boston at the annual conference of the National Council of Teachers of Mathematics (NCTM).The math coordinator was a member of the staff at Union College, New York PIMMS program in the summer of 1995. An administrator presented at the regional NCTM conference in Philadelphia. The leadership and influence of these district members continues to grow in and out of the state. Teachers who show exceptional potential are encouraged to become involved with PIMMS, the professional organizations, and other equally committed colleagues. Efforts are made to allow and encourage them to use these opportunities to present workshops to other teachers. The influence of PIMMS is extended to all activities involved with math and science as well as to other professional organizations, as members of the district are sought out to serve on such boards as the State Accreditation Board.

Previous to Montville's initial involvement with PIMMS, the mathematics program at the K-8 level was under-directed. There was no leadership or forward vision. When the current Mathematics Supervisor took over in 1987, there was no written curriculum for the district, no formal assessment plan, no formal review or practice activities outlined, no technology component, and no in-service program. Eventually, all of these elements were instituted in the district. There is a district assessment policy prescribing annual pre-test and post-test data. The district uses this data to write annual objectives to improve mathematics in the next academic year. This summer (1995) the curriculum has been revised both horizontally and vertically. Montville also does a lot of in-service training, offering programs during and after school which continue to be very well received. Montville takes advantage of the expertise of their PIMMS' Fellows in every way possible.

There have been noticeable gains in student achievement over the past ten years. Since PIMMS' impact, Montville has changed what and how mathematics is taught, and PIMMS is probably the greatest factor responsible for this increase. Just last year, the CMT scores in the fourth grade rose from 60 to 74 percent mastery. Although the sixth and eighth grade scores have not attained such levels, the district's goal is to see the scores in grade six rise from 42 to 55 percent mastery and the scores in grade eight rise from 46 to 60 percent. Administrators realize the loftiness of this goal and do not expect to reach it within one year, but they will continue to see it as the next step to success.

Montville has provided students with improved curriculum and course offerings as well as improved methods for teaching math. In addition, the district, under the direction of the elementary math supervisor whose understanding of curriculum projects and an interdisciplinary approach to instruction was directly influenced by PIMMS, has involved students with a number of extended opportunities to study mathematics and science concepts through integrated real world applications.

For example, in the Stone Container Project, sixth grade students completed a six week learning experience centering on the design, production, and recycling of corrugated boxes. A lab technician from Stone came to the middle school to show the students how to make blender paper and work on skills, such as measurement and the use of microscopes. Students then visited different stores to determine how corrugated boxes are collected for recycling. Afterwards they visited the Stone facilities in Montville to study the recycling process and the Portland facility to see how corrugated boxes are designed. The culminating activity was for students to design and build a corrugated container to meet some exact job specifications. The project earned a Celebration of Excellence Award for the supervisor and her colleagues and was televised as a segment of CPTV and the Connecticut Academy for Education in Mathematics, Science, and Technology's Excellence Within Reach

Program. In addition, the Stone Container Corporation is having a video tape of the project professionally edited for national and international distribution to all of its plants as part of its program to highlight successful projects involving schools and corporations.

Projects such as this have contributed to a constantly increasing sense of pride emerging in the community for its schools and their achievements, especially in the areas of math and science. The exposure the district received after its appearance on CPTV has been nothing but positive. Teachers and administrators involved in the project constantly receive positive comments and recognition for their work from students, parents, community members, and others around the state who have become familiar with the work being done in Montville.

The positive image established by the school district has led to many successful business alliances between the district and the community, with the Stone Container Project being one of the best known. Small businesses in the community have heavily invested in programs and provide many opportunities to the students. There is a vested interest in our achievement. We receive a great deal of support for programs such as the recent Math Movers Program in which a group of students from three surrounding towns worked together to build a computer from scratch.

Next year the plans are to work with the Eli Whitney Museum and a real inventor to teach kids in grades three through six the process for inventing. The final goal of this project is to have the students enter the State Science Convention.

The community is involved and excited about education in Montville. They cannot wait for the next project idea to emerge. The training and influence of PIMMS gave the district the direction, confidence, and knowledge it needed to establish and maintain these alliances, further impacting students in mathematics and science.

As awareness grows and excitement mounts, parents become more involved and satisfied with the school. The Family Math nights organized by the Math Supervisor, as a result of her PIMMS training, have been very successful. Attendance has ranged from 80 to 150 parents, with school administrators taking active roles in events offered during the evening. These programs have also led to the development of a community newsletter and press coverage, items which further increase the support of parents.

When the district first revised its curriculum to be more hands-on and reflect the current trends and approaches promoted by PIMMS, a parent advocacy group operating within the school and through the administrative offices was not pleased. After reviewing the curriculum, experiencing some of the techniques, and discussing

the processes with teachers who really understood the curriculum, the parents were so impressed they requested that a segment concerning the changed curriculum be broadcast on another Excellence Within Reach program. In addition, the number of parent volunteers for activities and field trips has grown so large that many have to be turned away. The parents, through the PTO, support every initiative and effort Montville makes in the areas of math and science.

PIMMS' influence in Montville has been tremendous because of the dedicated people involved with the project and the strong administrative support provided by the district personnel and the Board of Education. Montville treats teachers like professionals and PIMMS expects teachers to be professionals. Most Fellows are confident with their roles and serve as leaders for other teachers. They are aware of the resource potential available throughout the state and have immediate access to all of it.

PIMMS is involved in every aspect of math education in the state of Connecticut. Montville needs and appreciates these connections and hopes to see them maintained and continued. The support provided in all areas formally and informally, directly and indirectly, by PIMMS must be maintained if PIMMS is to continue to have a positive impact on Montville.

Stratford

Stratford is located in Fairfield County contiguous with Bridgeport. It has a population of approximately 50,000, which includes a substantial number (20%) of senior citizens. The population is diverse with a broad range of socioeconomic classes and a 13 percent minority rate. There are approximately 8,000 students in the school district with 23 percent classified as minorities. There are fifteen schools in the district: nine elementary, two middle schools, two high schools, and two magnet schools under the Stratford Academy. The latter schools have a slightly greater focus on technology and are composed of small, twenty-student elementary school classes that represent the racial balance of the community. They are located in the section of the district where many members of the minority populations live and, thus, help achieve the state's guidelines for racial balance in the schools. Stratford has been under a state order to improve its school enrollment policies for over ten years.

The following statement is a sketch of Stratford's PIMMS program composed of quotes from the subjects:

"The current assistant superintendent and the previous math supervisor for the district were among the first PIMMS Fellows. At that time, the assistant superintendent held the position of math supervisor for the district. When she moved into a new position, she hired the previous supervisor to replace her. That there

were two PIMMS Fellows in positions of leadership in the district had a tremendous impact. The district was exposed to many new ideas.

Stratford worked with other PIMMS Fellows in 1985 to develop an applied math program to replace its general math curriculum. An emphasis on technology was outlined, since PIMMS had sent the two Fellows to California for a one-week institute on current technology. These Fellows became the leaders in the district in this area. Workshops were developed for the district and were extended to other districts. An advocacy group for this new type of instruction was also formed, since the assistant superintendent was also the president of ATOMIC at the time.

A real connection between the school, the professional organization, and the State began to develop. As more and more teachers became involved with PIMMS and its outreach work, many leadership opportunities for teachers and administrators were created. Upon the retirement of the math supervisor, another PIMMS Fellow, who had worked closely in this area, was appointed to this position of leadership. These key positions are in addition to the other leadership roles played by PIMMS Fellows in Stratford. Most Fellows here provide some sort of workshop training, are involved at all levels of curriculum development, and have become award winners. PIMMS has been a catalyst for PIMMS Fellows and the district itself to extend the reach of school reform. Additionally, the Fellows bring in money, such as BEST Grants, because of their commitment and training.

PIMMS has had a substantial impact on the curriculum and method of instruction used in the district. The opportunities for follow-up and the encouragement for advancing in these areas is kept alive through PIMMS. PIMMS also opens doors for other programs and opportunities. For example, it was the PIMMS connection that enabled the district to solicit funds from Pitney-Bowes for a sixth grade remedial assistance class. A substantial number of teachers are still interested and apply for that summer program. Last year ten teachers applied and six were accepted. Part of the desire to attend is the modeling done by PIMMS Fellows in the district. Their ever-present and increasing efforts have enabled Stratford to surpass the achievements of other districts in mathematics and science.

Not all of the leadership activities of those persons influenced by PIMMS have been documented, since there have been so many. In Stratford, PIMMS Fellows sit on the K-8 Math/Science Leadership Council and take new ideas back to buildings, where they serve as resource people. Many of those influenced by PIMMS volunteer to be on curriculum and assessment committees.

PIMMS is like a seed sprouting a network of leaders throughout the state. The PIMMS Fellows' leadership has had a major influence on the use of technology and

the advancement of math and science education in the schools. Those leaders are provided with and provide a number of opportunities for staff development. PIMMS motivates teachers to achieve in ways they never thought possible for themselves.

In the early 80's, science and math instruction in Stratford was second-rate. Through the constant influence of PIMMS and the Academy for Education in Mathematics, Science, and Technology, math and science became critical focuses in the schools. A collaborative group formed with PIMMS, the Academy, the professional organization (ATOMIC), and the state—all pursuing the same emphasis. The communication between these organizations has fostered a strong cadre of leaders in math and science throughout the state. PIMMS Fellows and others influenced and connected to the program have a renewed strength. They have support for their ideas, a network of resource people to count on, and a desire to do more.

After Stratford's involvement with PIMMS, the teachers became excited about mathematics. They attended workshops and in-service sessions and brought new activities and ideas back to the district to share with other teachers and students. PIMMS' influence is extended across the district to all those not directly involved through the network and the outreach work of the Fellows. PIMMS has been a seminal organization in our district as well as in the state. All that is effective in math education has come directly or indirectly from PIMMS.

Stratford's mastery test scores in math have steadily improved. Major gains are especially evident in the minority achievement scores. This is a direct result of the Minority Advancement Program (MAP) begun in Stratford in 1988 by two PIMMS Fellows. Although not a PIMMS program, the awareness of successful minority programs in math is directly attributed to the PIMMS network. The PIMMS training gave the Stratford Fellows the direction they needed to initiate a program such as this in the school. In fourth grade, minority students who show academic potential, have a good attitude, and are good citizens are targeted by the program. Their academic achievement is monitored and they are encouraged to elect and stay with the most challenging math classes available throughout their middle and high school years. As a result of continued development of this program over the year, the SAT scores of the minority students in the high school rose 27 percent. Encouraging and pushing these students to succeed has had a dramatic impact.

In the next few years, Stratford hopes to extend this program into the non-minority groups in which other students with potential would also be strongly encouraged to achieve at higher levels. One way of extending this idea further is to emphasize algebra earlier; for example, in sixth grade. Next year Stratford has a PIMMS Fellow, who has expertise in algebra, coming in to help them adapt this subject for the lower grades, so that more students are involved in the more advanced math

levels sooner. The district's PIMMS Fellows and resources are always available to provide whatever is needed to improve math education in the district.

Another development directly or indirectly influenced by PIMMS, which has had an impact on student achievement, includes the removal of general math classes for the lower level students and replacing them with an applied math program that inspires those students to participate in higher level math through more hands-on and applied activities. PIMMS teaches that more children are capable of greater accomplishments if the district structures the content properly and uses appropriate instructional techniques.

Stratford is using activities and course changes like these to make improvements in the weaker areas of math instruction. Now, when the district sees lower CMT or SAT scores, the teachers and administrators are better able to diagnose the problems or weaknesses. Then, a committee of teachers, many of whom are PIMMS Fellows, develops, on their own or through the additional resources of available programs, the means to directly remedy these issues.

In addition to academic course work, a member of the Stratford teaching staff has also become involved in the Multiply Your Options Program for young girls in our community and surrounding communities. Through discussion groups, girls meet with professional women from fields related to science and math. They realize the need to expand their options early. The schools work with this program, encouraging girls to continue taking more and higher level courses. PIMMS, the schools, related organizations, and the state work together on all of these programs, supporting each other's accomplishments and goals.

Parents were anxious when Stratford changed the focus of its math curriculum. Through the successful Family Math nights they have grown to understand this process better and are generally pleased and supportive. Family Math, a program brought to Stratford through a PIMMS connection, has really helped parents become involved. The original training for this program occurred some years ago.

Last year a PIMMS Fellow came to the district and trained a dozen new teachers. Most of these new teachers are involved in Chapter I programs. After the training these teachers provided workshops for the Chapter I parents, encouraging them to take a more active role in their child's education. The most active group of parents is those involved with MAP. To date their are thirty active parents who meet every month as a steering committee for this program. They assist with the overall development of the program and raise scholarship money. Last year scholarships were awarded to minority students attending such schools as Brown and MIT. These parents have even worked on establishing peer mentoring and tutoring situations and

social activities in which successful minority students meet students of similar ability. Before this program, participation was rare in the minority communities. Now these minority parents are an integral part of this program. They even keep in contact with graduates, providing additional support while the students attend college. The future goals for this program are to extend the reach of science, bring it to the lower grades, and add a language component. This is one of the district's most successful student programs and it came through our connection to PIMMS.

The contributions from PIMMS serve as a catalyst for community pride. Stratford is constantly receiving recognition for its math programs. These achievements also lead to contributions from the community in order to continue this work. All of the academic scores have risen and Stratford's achievements have impacted on all the educational agencies in the state. The motto in Stratford is "Children First." The contributions PIMMS has made to our school have followed this motto. Even the senior citizens are beginning to notice the improved mastery levels.

In fact, over a ten year period Stratford continues to have the highest percentage gain in the most number of students who achieve mastery in mathematics across the state. This result is directly attributed to the focus math received from the district after its introduction to PIMMS. A Stratford leader in the state math organization once had an opportunity to informally meet with a number of state leaders of the NCTM affiliates. As a description of PIMMS emerged, envy was evident from the group.

Connecticut is very lucky to have PIMMS.

The greatest factors in Stratford, which have impacted on the success of PIMMS in the district, are the commitments of the district administrators and teachers to the ideas of the project and the continuous involvement of the project in the school district. Again, it is a cyclical process with each element supporting and reinforcing the other elements. As a result of this dual commitment, Stratford continues to see growth in its math and science programs and in the achievement levels of its students, especially in the minority population. Initially teachers received free training from PIMMS by the best people in the field from all over the country. Stratford then worked hard to develop an effective in-service program, which would enable Fellows to disseminate this knowledge across the district, allowing the influence of PIMMS to be felt at every level and in every math and science classroom in the district. The leadership of the PIMMS Fellows to make this work for Stratford is to be commended.

To continue to serve the needs of Stratford, PIMMS must continue to be in the forefront of science and mathematics education in the state. Newsletters,

information, and programs must be available and are vital to its continued mission to improve education in the state. Follow-up and continued updates for those already involved should be available. An opportunity to have newer teachers trained is a must in a district such as Stratford, where a large group of new teachers has been hired in the past two years. PIMMS' continued focus and the number of dedicated Fellows in the district will keep the program alive."

Colleges and Universities

The connection between teacher education programs at institutions of higher education and PIMMS is through a few professors who either are on the PIMMS staff or are PIMMS Fellows. Teachers who have taken courses from PIMMS Fellows recognize their influence. Some teachers voiced regret that the PIMMS model is missing from the pre-service programs. Ideally those programs should merge easily with the PIMMS in-service, and they could eventually work in cooperation to provide professional development for beginning and experienced teachers. Bob Rosenbaum, in association with Project CONNSTRUCT, has tried numerous times to make connections between classroom teachers and university professors by appealing to their shared desire to improve the quality of instruction in Connecticut. With the exception of individual science and mathematics faculty members at colleges and universities across the State, almost no substantial relationship exists. According to a professor at Southern Connecticut State University, the reputation of PIMMS in the areas of mathematics and science education is intimidating to the university educators, who are often too busy doing "college things" to devote time to in-service programs.

During some interviews, teachers and administrators made reference to pre-service education. One school administrator complained that new teachers have not studied any current trends, research, or content in their undergraduate programs. One PIMMS Fellow was not as polite in his comment that "college is so removed from the real world that there is nothing useful there." It trains you to do "squat," he said. A middle school math teacher said that PIMMS far exceeds any education course. A university professor and PIMMS staff member confirmed this assertion and questioned the feasibility of PIMMS training for beginning teachers whose pre-service training is so diluted that they are unprepared for the content challenges of PIMMS. "Beginning teachers are inexperienced and unreflective," he said. "It's only after five years of real teaching that they are able to understand and appreciate the PIMMS model." The consensus is: experienced teachers can be motivated to explore substantive changes in their instruction. And PIMMS is the in-service program that is the most vital factor for improvement of mathematics and science education in Connecticut.

Individuals

PIMMS has enjoyed, and continues to have, the greatest long-term, sustained impact on individual teachers who become involved in the intense summer in-service program. One does not expect state department officials, university professors, school administrators, students, and community members to have direct involvement, if any, with PIMMS. However, teachers make a long-term, often lifetime, commitment to PIMMS. In return they are stimulated personally and professionally by this program. With few exception, teachers say that PIMMS is the best thing they ever did for themselves. One teacher likened it to a religious experience, saying, "It changes your whole attitude and outlook both professionally and personally." Another teacher said, "PIMMS opened up a new world for me, one I never knew existed and would not have been exposed to....I owe a lot of who I am now as a teacher and as a professional to PIMMS. It was more than just an in-service program."

Teachers said that through PIMMS they were introduced to people throughout the state who had similar experiences, interests, and goals. Many of these connections developed into personal and professional friendships. PIMMS Fellows also reported that they feel more confident and are more assertive. "They are a group of radicals against the status quo of education," one teacher said. Many teachers discovered that they have developed leadership skills, grown as people and as teachers, and are receiving new respect from colleagues and other professionals. Most of these teachers now have the courage to try new things and take risks. A few have enjoyed the opportunity for extended study and have enrolled in doctoral programs. One administrator, a previous teacher, remembered that PIMMS was somewhat different when he participated. He said, "Back then the program was very heavy in content and those of us involved had free run of the University. Many of us took dozens of extra courses and earned additional degrees."

Some PIMMS Fellows have made career advances or changes. A few have taken leadership positions in the state professional associations. One moved to New Hampshire to become a representative for Addison-Wesley. Some have moved into administrative positions. A former teacher, who is now an elementary school principal, said, "I used to be language-oriented as a teacher, but, after PIMMS, I realized how much I loved math. I became a principal, in part, to raise interest and enthusiasm in this area." Similarly, a middle school math teacher discovered that she "loves teaching night courses in a local college to adults who are terrified of math." Her goal is to build their confidence, skill, and enthusiasm in mathematics.

PIMMS has a positive effect on every teacher involved in the program. "It is the first program I have ever been involved with that treated me like a professional," said one middle school teacher. As a result of the heightened self-confidence and professionalism, most of these teachers became instructional leaders in their buildings. They offer workshops, model lessons, and consult with their colleagues. Some have extended their reach to other districts

in the state, to the state professional organizations, and to education systems and organizations outside of Connecticut. The PIMMS-trained teachers are involved in local and state initiatives; win proportionally more local and state teaching awards, such as the Teacher of the Year Awards and the Presidential Awards; and set a new standard of professionalism.

The following incident involving a middle school teacher illustrates the new self-confidence and principled activism to which PIMMS Fellows aspire:

> *"During a previous summer, middle school teachers from around the district were working on the city math curriculum. An issue came up in which I, as well as others, disagreed with the city's stance. Most teachers conceded that we would have to do what the city wanted. I told them that I would not put my name on this unless it's the way I want it and the way it should be. Then, I walked out. My name means something and I won't put it on garbage. PIMMS has given me a real fierceness of conviction."*

The most important and often-mentioned impact of PIMMS on individual teachers is the informal establishment of the large network of education professionals in Connecticut. PIMMS has acquainted and connected teachers, administrators, and others who have similar professional goals and interests. The informal network provides a support system for ideas, serves as a resource center, and performs an instrumental role for improvement of mathematics and science education. Whenever these teachers need something or have a question, they know where to find the answer or where to seek help. Steve Weinberg, State Science Consultant, said that PIMMS has formed a network of professionals who are involved in all areas of professional and curriculum development in the state. Likewise, a math teacher remembered that before PIMMS he was "basically uninvolved," but now, with the PIMMS experience, he has the connections he needs, and he is considered one of the top agents of change in the western region of Connecticut.

Quantitative data from the survey showed all groups in agreement (average of 3.5) that PIMMS substantially improved teachers' leadership ability, effectiveness with classroom instruction, self- confidence, and professional work on state, regional, and national levels.

State of Connecticut

PIMMS is seen by teachers and school administrators as a lighthouse for improvement of math and science education in Connecticut. It highlights the importance of improving these areas of the curriculum and updates instructional methods. Connections between PIMMS, the Fellows, and the State Department of Education have led to new developments and directions in math and science education and teachers' in-service. As a result, state-sponsored activities, programs, and standards are better understood, supported, and promoted. The renewed interest in math and science education in Connecticut encourages

and supports creation of professional organizations, like CAPT and programs such as Project CONNSTRUCT.

Teachers who take advantage of the connections and opportunities available through PIMMS, are helping to raise the standard of teaching in Connecticut. PIMMS Fellows influence teachers all over the state through workshops and in-service programs. Classroom instruction reflects the best of current research and incorporates modern technology. The result of their collective work is a positive impact on increasing numbers of students.

PIMMS has put Connecticut on the map in science and math education. This program is copied elsewhere in the country. With expressions of pride and disappointment, one teacher said, "The state needs to recognize what it has. In 1980, we tried to improve education by revamping the teaching profession. In 1985, we tried again by instituting the mastery test. By 1995, we should know the answer. PIMMS is the single best way to improve education in the State of Connecticut."

Claims

The two primary functions of the PIMMS program are to improve the quality of instruction in mathematics and science and to expand the role of the teacher. PIMMS follows a theoretical framework consistent with current research which promotes a sustained institute with follow-up, practice, and updates. By design, PIMMS is a complete program emphasizing both content and pedagogy, and is structured so that teachers model the most effective methods of instruction.

The objectives of PIMMS are to extend the classroom teachers' command of subject area knowledge, to increase their understanding and use of technology, and to improve their ability to teach. These are the means by which the PIMMS staff assists teachers in valuing their own worth and becoming better, more effective professional educators. With increased self-confidence and competence, PIMMS Fellows continuously expand their horizons and serve as resource teachers for others throughout the state. The long-term goal of the PIMMS model is to increase student mastery in science and mathematics and to insure that the distribution of success is more equitable.

Results

By all accounts PIMMS is meeting its goal. The quality of classroom instruction is improving steadily. District curriculums and school instructional plans are being revised, improved, and updated. PIMMS Fellows usually are directly responsible for this work. Teachers are modeling, consulting, and providing workshops and in-service programs in their districts and throughout the state based on the PIMMS instructional models for science and mathematics. Education professionals across Connecticut consider PIMMS to be the best source of professional development available. Its strength as an in-service program is its in-

depth and thorough design. In one district, the school administrator praised PIMMS "for the long-term, ongoing style of their program in which the district participated all year long." A middle school teacher said, "PIMMS teaches us to 'fish'. Once you have been shown how, you can do it yourself and show others."

Another strength of PIMMS is its academic content. The in-depth study of mathematics and science content benefits all the teachers and their students. Teachers who already possess a solid background in their content areas supplement and update their knowledge. For a majority of the elementary and middle school teachers, PIMMS is their first real exposure to pure math and science. As a result, they learn how to teach their content area, so that students have a true understanding and grasp of that knowledge. Instruction is improved also, because many teachers better understand what methods they are using to teach and why. Similarly, skill in the use of current instructional technology enables these teachers to expose students to the most up-to-date content in the fields of math and science. The effects are positive in classrooms and district curriculums. After PIMMS, many teachers ask their administrators to purchase this equipment. Then, they work with other teachers in their building on its use. This "working together" provides students and colleagues with valuable knowledge and skills to carry them into the future.

PIMMS created a cadre of self-confident professional teachers in the State of Connecticut. It raised the standards for teaching to a necessary, higher level. PIMMS Fellows are known as the instructional leaders in math and science. They are active in all the professional organizations and have a far-reaching impact. PIMMS-trained teachers are the agents of change in Connecticut's education system. They conduct peer training exercises, district-level workshops, and state-wide in-service. They pursue improvement of mathematics and science education in spite of institutional resistance. Some have extended their influence by moving into leadership positions within the schools and the state. PIMMS Fellows and the PIMMS program impact increasing numbers of educators and students, bringing positive and much needed change throughout Connecticut.

PIMMS experienced its greatest success with teachers, where its principal interest has always been registered. Had there been time to do comprehensive studies of other communities, in addition to what was done with Montville and Stratford, we might have found some statistically significant results. Teachers are certain of the effectiveness of the instructional methods from PIMMS and request more follow-up sessions. Restructuring the curriculum proceeds at different paces in different districts. The reasons for these differences are individual strengths of teachers, the school's budget, teachers' time for planning and instruction, and cooperation of colleagues and supervisors. Where social and extracurricular issues occur, teachers lose time that would otherwise be spent on academic content. Consistency, intensity, and interest may be sacrificed. Occasionally a school's administration

will resist when teachers request materials, time, and situations that support effective

instruction. Administrators and teachers know that increased enrollments, decreases in staff, scheduling conflicts, and lack of quality substitute teachers curb effective teaching and lessen the impact that PIMMS can have in a district.

Measures

Many of the results presented in this report come from the analysis of oral responses to a formal survey. The subjects did not provide statistical data to support their claims. Additional support for the findings is drawn from subjects' personal observations and their first and second hand accounts of incidents and events.

The record of PIMMS' achievements as provided by university professors, administrators, and teachers is primarily based on subjective descriptions. That these results are based largely on subjective data does not lesson the value of the findings in the least. Descriptive details often can be more convincing than statistics. They indicate new directions for the subsequent evaluation of the project and, frankly, acknowledges the difficult challenge faced by every project that strives to improve education, including PIMMS.

The PIMMS staff maintains the following schedule for internal evaluation and regularly reports its findings to appropriate agencies.

- During each summer program, a weekly evaluation is completed by participants to determine the program's progress toward its goals and objectives and to provide staff with information for mid-course corrections, if needed.

- At the conclusion of each program, a detailed questionnaire is completed by each participant. This provides information on the effectiveness of the summer program, the degree to which the program has met its goals, and feedback to PIMMS staff for future planning.

- During January and February of each year, a mid-year survey is sent to each Fellow who participated in a program during the previous summer. Questions are asked regarding the changes in curriculum, changes in teaching, implementation of ideas learned during the summer program, and the extent to which the Fellow has disseminated ideas to other teachers.

- At the conclusion of any program that receives support from the State Department Eisenhower program, State Higher Education Eisenhower program, National Science Foundation, or other foundations, a report is submitted to that agency on the project's success in meeting its goals, extent to which Fellows have implemented changes in teaching and curriculum, and extent of dissemination of new ideas to other teachers.

- Throughout its history, PIMMS has maintained contact with Fellows who have completed PIMMS programs. Periodically, information is sought from school administrators, funders, and others regarding the effectiveness of PIMMS programs and the extent to which PIMMS is contributing to the improvement of mathematics and science education in Connecticut.

The PIMMS office maintains the records of all evaluation instruments for individual programs and the reports that are completed at the end of summer programs, mid-years, and final reports.

Administration

Data collected on the PIMMS program conveys the deep respect teachers and administrators have for the PIMMS staff. The leadership of PIMMS is described as "dynamic." Many participants expressed their high regard for Bob Rosenbaum. They hold him in high esteem as a person and as the leader and main architect of PIMMS. He is seen as the key influence in many teachers' careers. "The best of PIMMS is Bob Rosenbaum," said one teacher. The leadership of Dan Dolan and Wilma Toney is seen as promising a continuation of PIMMS' excellence.

The State Department of Education Math and Science Consultants and PIMMS associates (Steve Leinwand, Mari Muri, and Steve Weinberg) are seen by the teachers as effective liaison personnel with this program. They model instructional techniques and activities and assist in the development of curriculum for teachers and districts throughout the state. The examples they set have encouraged a number of teachers to become involved in PIMMS.

PIMMS instructors are next in line to receive praise from teachers and administrators. Most teachers maintain that "these instructors are the best in their fields." To some teachers, they are the "greatest strength of the program. They know how to make the complex simple and try to tailor the program to the needs of the participants." The examples set by instructors, like Ralph Yulo, are highly respected and greatly appreciated by the teachers.

The PIMMS Fellows also carry out the mission of PIMMS. They are seen by teachers and school administrators as the most active participants in science and math education in Connecticut. PIMMS Fellows are the leaders and resource people in their schools and districts.

The group that received criticism, albeit minimal, was school administrators. Teachers said that some administrators do not recognize the need for PIMMS training and, therefore, do not lend as much support as the program requires. However, this resistance from some school administrators is declining as more and more educators realize the influence of PIMMS. In most schools the administrators clearly recognize its benefits and are very supportive. They

provide funds for equipment and materials, support a budget for continued staff development opportunities, allow and encourage active involvement of teachers, and provide instructional settings that are most conducive to effective instruction.

To conclude, PIMMS is seen, by everyone who participated in this study, as the premier professional organization for the ongoing improvement of mathematics and science education.

5. Themes and Conclusions

This section presents themes and conclusions drawn from data collected in interviews with the different participants in the PIMMS program and documentation provided by the PIMMS staff.

Although several questions guided this study, the main question is: Has PIMMS done what it aimed to do? Yes, without qualification. Feature-for-feature, there is no other in-service program for mathematics and science teachers in Connecticut that compares to PIMMS, nor is there another educational program of comparable worth. That is the virtually unanimous opinion of participants in this study—the state's educators who are the principal beneficiaries of PIMMS.

Major

PIMMS' major themes are the improvements, introduced and sustained, for the professional development of teachers, the profession of teaching in general, and the effectiveness of instruction in mathematics and science in particular. Due largely to PIMMS training, teachers are more confident about their use of content and methods and are more effective with their classroom instruction. They see themselves as professional educators. They assume responsibility as the instructional leaders in their schools, districts, and often elsewhere in the state (see Appendix). PIMMS Fellows are involved at all levels of curriculum development, have instituted the state's professional organizations, and established a higher standard for teachers in Connecticut. Teachers' instruction has improved as a result of their involvement with PIMMS and their expanding professional connections. They continue to improve their knowledge base in their different specialties, use advanced technology to facilitate teaching and learning by teachers and students, and make substantial numbers of students more excited about learning mathematics and science. Students' enrollment in advanced science and math courses is increasing as is their interest in all aspects of these subject areas at all levels.

An important product of PIMMS is the informal state-wide network of professional educators. Teachers who participate in the summer institutes form affinities that last a lifetime. They stay connected with each other and socialize on personal and professional bases with past and future PIMMS Fellows. Teachers have a network of "friends" who have similar beliefs, commitments, and goals. This informal network keeps the Fellows connected and maintains their commitment to the program. All PIMMS Fellows are available to provide services that maintain and promote the ideals of PIMMS for the improvement of science and mathematics education in the state. They have made a lifelong commitment to this program and their commitment is the life blood of PIMMS. Maintaining the network of professional

educators is one of the great successes of PIMMS. As they say, "Once a PIMMS Fellow, always a PIMMS Fellow."

A final theme—obvious throughout the documentation from the PIMMS staff and interview data—is the desire of PIMMS Fellows from all levels to continue their commitment and involvement in the program.

Criticism of PIMMS was scant and always constructive. Some teachers regretted that their own grade-level of instruction was omitted from the summer program and asked that it be re-instituted. Others wanted all the programs from the past to be revisited and updated. Some teachers are concerned that too few teachers in any building are involved to really make substantive changes and want more teachers to be included in the program or want the program to be run more often. A great number of teachers and administrators said they want the program expanded to include advanced sessions for teachers already experienced in PIMMS. No one wants to let go of their connection to PIMMS.

Minor

Minor themes are the lack of community awareness, limitations caused by "typical school" problems, and lack of significant statistical achievement data on students. The PIMMS program is seen as one of the best innovations for the in-service education of teachers. It increased teachers' effectiveness with instructional methods and it improved mathematics and science curriculums. Still, most community members are unaware of its influence in their local school district. Many teachers believe that additional public awareness initiatives are necessary to highlight some of the good things happening in schools and to increase the name recognition of PIMMS.

A long-term goal of PIMMS is to improve students' science and mathematics achievement scores in Connecticut. This study shows that PIMMS has a profound effect on teachers, improving their knowledge base and their instructional techniques. Teachers report that students' interest and participation in science and mathematics is increasing. However, as with other projects, improvement of students' achievement levels remains elusive. Teachers can not disregard hard data because administrators and parents will question the benefits of programs that claim to improve students' achievement but do not demonstrate positive gains by test results.

A third and related theme is the negative impact on the PIMMS program of large classes, unprepared students, and schedule conflicts. Some teachers say they are burning out early in the year as they struggle continuously with classes that are too large to teach effectively, especially when a large number of students is poorly prepared academically and has behavior problems. Teachers said they need to be re-energized in order to maintain the level of commitment necessary to meet these challenges. For a PIMMS Fellow, networking with

colleagues is the best way to reinvest in this process. Unfortunately, the large class size makes it impossible for teachers to leave their classes to work and plan with other teachers. Fixed schedules to do not allow shared time or release time for professional development. Teachers who have designed effective programs and have the desire to implement them sometimes must revert to traditional methods to manage the problems they face locally.

6. Recommendations

The following section presents recommendations for the future development of PIMMS. In all instances these recommendations are drawn from data presented by the subjects of the study. PIMMS is currently addressing some of these recommendations.

Immediate

- Maintain the current staff, intensity, pure content, and structure of the program provided during the summer. But increase the number of seats so that more can participate.
- Provide shorter workshops for teachers during the school year for teachers who can not attend summer fellowship programs.
- Continue to include elementary and middle school teachers in the summer program.
- Allow districts to prioritize applications, if seats are unavailable for everyone.
- Reinstate the high school summer fellowship program.
- Consider expanding the Shelton model for districts that are interested in a tailor-made program focusing on the district's needs and increasing student achievement scores.
- Train a few substitutes who can serve as resource persons and provide PIMMS Fellows with release time to work with other teachers or on workshops.
- Target, for PIMMS training, experienced teachers who are disenchanted with the same old professional development programs.
- Help teachers and school districts reach out to parents and community members.

Long-Term

- Train more teachers to establish a critical mass of PIMMS Fellows in the state, insuring real, lasting change.
- Expand programs to include advanced stages for those already familiar with the PIMMS program.

- Obtain long-term funding so the focus can be entirely on education.
- Align the program with Connecticut's new professional development requirements.
- Provide competitive stipends during summer so that everyone has an equal opportunity to participate, rather than opting out to earn more money at a summer job.
- Help to establish an understanding between the state and the school district to provide release time, so teachers can participate in staff development programs that reinforce and promote the goals of PIMMS and the state.
- Periodically schedule refresher courses and reunions for former PIMMS Fellows.

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Biographical Sketches

Curriculum Research and Evaluation is a firm that is devoted to research and development of programs in the field of education. CRE's specialities are: (1) to provide services in order to evaluate the quality of education programs for private business and industrial companies, public and private funding agencies, and schools; and (2) to develop and guide the implementation of curriculum and instruction.

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